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THE EFFECT OF TEMPERATURE ON THE REGENERATION OF HYDRA.

FLORENCE PEEBLES.

It has been shown that temperature has a marked effect on the regeneration of *Planaria torva*. Lillie and Knowlton (2) have proved by experiment that the optimum temperature at which regeneration is completed is $29^{\circ}.7$ C.; the minimum, about 3° C.

During the last month I have made a series of experiments on *Hydra viridis* and *Hydra grisea*, in order to test the effect of temperature on the regeneration of the hypostome and tentacles. A transverse cut was made through the reproductive zone of the polyp just posterior to the ring of tentacles. The body thus deprived of hypostome and tentacles was subjected to a gradual rise of temperature. The dishes in which the *Hydras* were placed after the operation were partially submerged in a water bath in which the temperature varied from 26° to 32° C. Readings were taken during the day at intervals of four to six hours; the variation was never greater than five degrees. Control experiments were made at room temperature, which ranged between 18° and 24° C. Observations were made at intervals of twelve to twenty-four hours, and regeneration was considered complete when the new hypostome and tentacles had attained their normal size.

Normal *Hydras* were also placed in the water bath, in order to determine what degree of warmth the uninjured polyps could endure without apparent disturbance. In one series of experiments the temperature was raised to 38° C., and as a result not only the injured, but the normal, polyps died. At the end of several hours they had completely disintegrated.

That the rise of temperature up to 32° C. produces a marked decrease in the time required for regenerating the lost parts is seen in the following tables. In Table 1 the range of temperature and the percentage regenerated at a given time are

recorded. Forty-six individuals were used in a series of six experiments.

TABLE 1. — HYDRA VIRIDIS.

TEMPERATURE.	PER CENT REGENERATED.	
	48 hrs.	72 hrs.
26-27°	100%	100%
27-30°	97%	100%
28-30°	88.9%	88.9% (1 dead)

The rate of regeneration in Table 1 may be compared with the rate for *Hydra viridis* at room temperature, given in Table 2, where the results from forty-five individuals in eight experiments are given.

TABLE 2. — HYDRA VIRIDIS.

TEMPERATURE.	PER CENT REGENERATED.	
	48 hrs.	72 hrs.
18-24°	37.8%	100%

It is readily seen that the number completely regenerated at room temperature in forty-eight hours is much smaller than under higher temperature.

In a recent paper (3) I noted that the rate of regeneration of *Hydra viridis* is much more rapid than that of *Hydra grisea*. In connection with this it is interesting to find that when the temperature is raised there is a larger reduction in the time required for regeneration in *Hydra grisea* than in *Hydra viridis*. Table 3 is the record of twenty-eight individuals in five experiments.

TABLE 3. — HYDRA GRISEA.

TEMPERATURE.	PER CENT REGENERATED.	
	48 hrs.	72 hrs.
26-27°	80%	100%
27-32°	70%	100%

At room temperature, *i.e.*, 18–24° C., the regeneration is much slower. In five experiments, in which nineteen polyps were injured, there was no regeneration completed at forty-eight hours; and at the end of seventy-two hours a very small number were complete, as Table 4 shows.

TABLE 4. — HYDRA GRISEA.

TEMPERATURE.	PER CENT REGENERATED.		
	48 hrs.	72 hrs.	96 hrs.
18–24°	0%	26.3%	94.7%

In order to show the great difference in the rate of regeneration of the two species and the effect of the higher temperature, a record, in which several sets of experiments are combined, is given in Table 5.

TABLE 5. — COMPARISON OF H. GRISEA AND H. VIRIDIS.

TEMPERATURE.	PER CENT REGENERATED.		
	48 hrs.	72 hrs.	96 hrs.
<i>H. grisea.</i>			
18–24°	0%	26.3%	94.7%
26–32°	75%	100%	100%
<i>H. viridis.</i>			
18–24°	37.8%	100%	
26–30°	98.5%	100%	

Owing to lack of material, I was unable to try the effect of lower temperatures on *Hydra grisea*. The results obtained from a series of five experiments on *Hydra viridis* show that when the polyps are subjected to cold, regeneration is greatly retarded. Table 6 is the record of thirty-eight individuals at a low temperature where the thermometer was kept at 12° C.

TABLE 6. — HYDRA VIRIDIS.

PER CENT REGENERATED.				
96 hrs.	120 hrs.	130 hrs.	144 hrs.	168 hrs.
13.1%	23.7%	34.2%	71%	100%

The change in appearance of the injured region was so slight from day to day that observations were less frequent than in the experiments where the temperature was higher. It will be seen from Table 6 that by a lowering of the temperature a delay of twenty-four to ninety-six hours results in the process of regeneration. On the other hand, an increase of temperature brings about an increase in rapidity of the rate of regeneration of twenty-four to forty-eight hours for *Hydra grisea*, and also a slight increase for *Hydra viridis*.

While making these experiments with temperature, I tried the effect of colored lights upon the regeneration of *Hydra*. Four colors were tested — red, blue, green, and yellow. These colors were obtained by making solutions of congo red, copper sulphate, anilin green, and potassium bichromate, respectively. These were tested with the spectroscope and found nearly monochromatic.

A number of experiments were made and also control experiments in darkness and in diffuse daylight, but the process of regeneration was in no way influenced by any of the colors.

The experiments noted here were made in the Physiological Laboratory of Bryn Mawr College, and were directed by Dr. J. W. Warren, to whom I wish to express my thanks for suggestions and assistance.

BRYN MAWR, PA.,
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